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ABSTRACT

To assist the College Board Calculus Development Committee in arriving at a decision regarding the policy that should be followed in allowing the use of calculators on the Advanced Placement (AP) examinations after 1980, a questionnaire was developed. It obtains information from secondary school mathematics teachers about the extent to which calculators are used in calculus classes, the extent to which courses are modified because of the use of calculators, and the opinions of the teachers about how the use of calculators on the AP mathematics examinations would affect student performance. (MP)

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College Board
Program Report

P78-1

A SURVEY OF THE USE OF HAND-HELD CALCULATORS IN ADVANCED PLACEMENT CALCULUS COURSES

S. Irene Williams and Chancey O. Jones

SE 027 577

Educational Testing Service
Princeton, New Jersey

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S. Irene Williams and Chancey O. Jones

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Educational Testing Service with the
financial support of the College Board

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A Survey of the Use of Hand-Held Calculators in Advanced Placement Calculus Courses

S. Irene Williams and Chancey O. Jones

Background

Because of the increasing availability of hand-held calculators to students at various grade levels, the College Board Mathematics Advisory Committee and the College Board Mathematics Development Committees have become extremely interested in the impact of the calculator on the mathematics curriculum in general and on mathematics testing in particular.

At the present time, candidates are not allowed to use a calculator during the administration of any of the College Board mathematics examinations. This position was reached in the interest of fairness to the majority of students after consideration by the committees responsible for the development of the examinations and will continue to be reviewed as the use of calculators become more central to the curriculum. Until a study, or studies, can be conducted to determine when the existing policy concerning the use of calculators on tests should be changed, the Mathematics Advisory Committee has adopted the following principle:

> The primary purpose of the College Board examinations in mathematics in the Admissions Testing, Advanced Placement, and College-Level Examination Programs is the assessment of students' developed mathematical skills, concepts, and abilities as they relate to problem solving. While some problems involve basic skills of arithmetic, the incidental computations are not tedious and can be easily accomplished without the use of a calculator.
>
> Consequently, because calculators or other computing devices are not germane to the primary purpose of the present mathematics examinations, the use of calculators is not permitted at this time.

In recommending that the use of calculators on the existing examinations not be allowed, the Committee took into consideration the following factors:

(1) Not all students use calculators; those who do, use calculators that vary considerably in cost and sophistication.

(2) Existing College Board examinations were developed without the use of calculators in mind. Before the present policy can be changed, examinations will have to be developed with the presumption that calculators will be used.

(3) As a first step, relevant data should be collected for existing examinations based on their administration with the use of calculators permitted.

Of immediate interest was the policy regarding the use of calculators on the Advanced Placement (AP) examinations. Battery operated calculators may be used on the AP Physics and Chemistry examinations but not on the AP Mathematics examinations. The following statement, which appears in the Advanced Placement Course Description in Mathematics 1979-80, reflects the current opinion of the College Board Calculus Development Committee:

> The Development Committee is aware of the increasing availability to students of calculators and other computational devices. At this time the Committee does not believe that the use of a calculator or a similar device provides either a significant advantage or disadvantage to candidates taking the examinations. Therefore, calculators, slide rules, and reference materials may not be used in the examination room during the testing period.

The Committee periodically reviews and reevaluates this policy. To assist the Committee in arriving at a decision regarding the policy that should be followed after 1980, the authors of this report developed a questionnaire (see

Appendix A) to obtain information from secondary school mathematics teachers about the extent to which calculators are used in calculus classes, the extent to which courses are modified because of the use of calculators, and the opinions of the teachers about how the use of calculators on the AP Mathematics examinations, Calculus AB and Calculus BC, would affect student performance. The questionnaire was sent in April 1978 to secondary school mathematics department chairpersons in the United States and abroad. The College Board Calculus Development Committee will use the survey results summarized in this report along with other available information in deciding whether the current policy on the use of calculators on the AP calculus examinations should be changed at this time and new tests permitting the use of calculators should be developed. These new tests should measure problem solving ability and knowledge of concepts with awareness of the use of calculators in the curriculum and on the examinations.

Procedure

Because the major concern addressed in this survey dealt with the Advanced Placement Examinations in Mathematics, the questionnaire was sent to mathematics department chairpersons at the 2402 secondary schools that had 5 or more students taking an Advanced Placement examination in May 1977.

In an attempt to maximize the number of returns, the questionnaire was mailed to department heads just before the administration of the AP examinations in mid-May with a request for their return by May 25, 1978. Returns were received from 1547 schools, 64.4 percent of those receiving questionnaires. Responses were received from schools in 45 states, the District of Columbia, and 17 foreign countries.

The first seven questions were machine-scorable. A separate response sheet contained an open-ended question and provided space for additional comments or suggestions.

Results

The results of this study can be summarized by considering the responses to the questions that were posed in the questionnaire. The results of the questions are based on the 1403 responses that were machine scorable; the remaining responses were either incomplete, unprocessable, or received after the data were compiled.

Question 1. Select every statement below that describes the use of hand calculators in your AP calculus classes. Hand calculators are

	Number	Percent
(A) NOT permitted for any purposes.	128	9.1
(B) Permitted for use in doing classwork.	833	59.4
(C) Permitted during some but not all tests.	421	30.0
(D) Permitted during all tests.	313	22.3
Total not responding	27	1.9
Total selecting one or more of B, C, and D	1248	88.9

Of the total group of 1403 respondents, 1248, or 88.9 percent, indicated that they permitted some use to be made of the calculator in their calculus courses; whereas, only 128, or 9.1 percent, indicated that no use of the calculator was permitted.

Question 2. If calculators are permitted in your class, which statement best describes the policy you have regarding hand calculators?

	Number	Percent*
(A) No class time is devoted either to teaching or assisting students in the use of calculators.	717	57.5
(B) Some class time is devoted to assisting students in the use of calculators and/or in the solution of problems that are best solved with the aid of a calculator, but the course is not modified to include topics that are particularly suited to the use of the hand calculator.	413	33.1
(C) Use of the calculator is encouraged to the extent that the content of the course is modified to include such special techniques as the numerical evaluation of integrals and the "conjecturing" of certain limits with the aid of a calculator.	133	10.7

*The base used in computing these percents is 1248, the number permitting the use of calculators. Because some respondents selected more than one option, the total number of responses in the table exceed 1248.

Well over half of the respondents who permitted the use of a calculator indicated that no class time was devoted to teaching or assisting students in the use of calculators. Approximately one-third spend some time assisting students in the use of calculators, but have not modified their courses. Slightly more than one tenth had modified their courses to include special techniques that are particularly suited to the use of the hand calculator.

Question 3. If your answer to question 2 was C, for which of the following do you teach special techniques that make use of the calculator?

	Number	Percent*
(A) Numerical evaluation of integrals	109	82.0
(B) Conjecturing values of limits	101	75.9
(C) Evaluating functions	86	64.7
(D) Solving equations	54	40.6
(E) Changing coordinates	21	15.8
(F) Other (Please specify in comment section of survey.)	7	5.3

For three of the topics listed (numerical evaluation of integrals, conjecturing values of limits, and evaluating functions), considerably more than half of the respondents who had modified their courses to make use of the calculator indicated that they taught special techniques for these topics, slightly more than 40 percent taught special techniques for solving equations, and only about 16 percent taught techniques for changing coordinates. Very few indicated that they taught special techniques for topics not included in the list. Among the additional topics specified in the comment section were Simpson's rule and the trapezoidal rule.

*The base used in computing these percents is 133, the number selecting option C for question 2.

Question 4. If calculators are permitted in your class, what percentage of students use a calculator?

	Number	Percent*
(A) 100%	240	19.2
(B) 80% to 99%	303	24.3
(C) 50% to 79%	214	17.1
(D) 25% to 49%	208	16.7
(E) less than 25%	250	20.0
Total not responding	33	2.6

The responses to this question were distributed almost equally among the options. More than 40 percent indicated that at least 80 percent of the students in their classes use a calculator, but 20 percent indicated that less than 25 percent use a calculator.

*The base used in computing these percents is 1248, the number permitting the use of calculators.

Question 5. If calculators are permitted in your class, are they provided by the school district?

	Number	Percent*
(A) Yes	196	15.7
(B) No	1026	82.2
Total not responding	26	2.1

Over 80 percent of the teachers who permit the use of calculators indicated that calculators are not provided by the school district, although the responses to question 4 would seem to indicate that many, if not most, students enrolled in a calculus course have access to a calculator.

*The base used in computing these percents is 1248, the number permitting the use of calculators.

Questions 6 and 7. Both the multiple-choice and free-response questions on the AP calculus examinations are designed to minimize the amount of arithmetical computation. The opinion of the Development Committee is that the use of calculators on the present examinations would not appreciably affect individual student performance.

If the current policy were changed to allow the use of calculators, in your opinion what effect would this have on the performance of your students on the examinations as they are presently constituted?

	Calculus AB		Calculus BC	
	Number	Percent	Number	Percent
(A) Student performance would be significantly better	69	5.1	60	5.4
(B) Student performance would be about the same	1237	92.2	1033	92.7
(C) Student performance would be significantly worse	35	2.6	21	1.9
Total responding	1341		1114	
Total not responding	62		289	

Over 90 percent of those responding to these questions indicated that student performance on either examination would be about the same regardless of whether or not calculators were permitted.

Question 8. Approximately how many students in your school are currently enrolled in an AP Calculus course?

Number of Students	Number of Respondents	Percent of Respondents
1-10	298	21.2
11-20	480	34.2
21-30	287	20.5
31-40	133	9.5
41-50	65	4.6
51-60	42	3.0
61-70	20	1.4
71-80	14	1.0
81-90	4	0.3
91-100	7	0.5
110	1	0.1
200	2	0.1

The approximate number of students enrolled in a calculus course in the secondary schools that responded ranged from 0 to 200, with 50, or 3.6 percent, of the respondents indicating that there were no students enrolled in a calculus course. The most frequently reported number of enrolled students was 20. Three fourths of the schools had 30 or fewer students enrolled in calculus courses.

Comments:

Each of the response sheets received was read by one of the authors, and the comments concerning calculators* were recorded and then grouped according to the primary intent of the comments. The thrusts of these comments fall into three major categories: opposes the use of calculators (that is, supports present policy), favors the use of calculators, and accepts the use of calculators under certain conditions. The results of these comments are summarized below.

Comments Opposing the Use of Calculators on the AP Mathematics Examinations

Comment Made	Number
Opposed to the use of calculators on the AP examinations	152
Calculators are a hindrance to the student	51
Current policy should be continued	387

Comments Favoring the Use of Calculators on the AP Mathematics Examinations

Comment Made	Number
Favor use of calculators	109

*Comments which were not directly related to use of hand calculators are not included in this report but have been directed to the Advanced Placement Program Director for consideration.

Comments Indicating Possible Acceptance of the Use of Calculators Under Certain Conditions

Comment Made	Number
If permitted, should be used only on the free-response section.	28
Permit the use of calculators only if all students use the same type.	34
If permitted, guidelines must be established.	54
A study should be conducted to determine the impact of the use of calculators on the examinations.	37

Respondents who opposed the use of calculators on the examinations expressed two main concerns: one concern was primarily pedagogical and the other involved the variety and levels of sophistication of calculators and the difficulty of monitoring the types used. Respondents who favored the use of calculators thought that the tests should keep up with the times, that calculators are available and are being used by a majority of the students, and that prohibiting their use on the examinations is a disadvantage, at least psychologically, to students who regularly make use of them. The ratio of the number stating opposition to the use of calculators to the number favoring their use was approximately 3 to 2.

It is interesting to note that 387, or approximately 25 per cent of those responding, voluntarily indicated that the current policy should be continued. This opinion was the most frequently made comment expressed on the response sheet and was made by more than three times as many as made a comment favoring the use of the calculator.

The most frequently made comment concerning acceptance of the use of calculators under certain conditions was made by 54 respondents and indicated a need for the establishment of guidelines if calculators were to be permitted. These respondents expressed some of the same concerns expressed by those who opposed the use of calculators - the problem of some students having sophisticated or programmable calculators and others having less complex ones and the need for a policy regarding the kinds of calculators that could be used and ways in which their use could be monitored.

Summary, Conclusions, and Recommendations

The responses to the questions posed on the questionnaire used in this survey indicate that:

(1) Although almost 60 percent of the teachers permit the use of calculators for classwork and approximately 50 percent permit their use during some if not all tests, some teachers, 9.1 percent, still do not permit the use of calculators for any purpose, (2) only a small percentage, 10.7 percent, of the teachers have modified their courses as a result of the accessibility of calculators, (3) over one-third of the teachers are of the opinion that less than 50 percent of the students in their courses use a calculator, and (4) an overwhelming majority of teachers responding think that student performance would not be significantly affected on either examination if calculators were permitted.

Of the voluntary comments that were made, the great majority favored continuing the present policy, which does not permit the use of calculators.

The authors of this report believe that the questionnaire results strongly support the continuance at this time of the present policy, at least until the Development Committee obtains a better understanding of the use of calculators in and their effect on the curriculum and develops appropriate examinations. This opinion is further supported by the results of a questionnaire (see Appendix B) given to students in secondary schools in the Princeton area who had taken one of the AP Calculus examinations in May 1978. More than 90 per cent of the students had access to and experience in the use of a calculator. Approximately three-fourths of the students thought that they would not have done better on the examination if calculators had been permitted, and almost 70 percent said they would not have used a calculator if one had been provided. More than 70 percent

of the students thought that calculators should not be permitted for either section of the examination, and of those who thought that calculators should be permitted, more than half were of the opinion that only nonprogrammable calculators should be allowed. Although this student survey was very limited and the results cannot be generalized to other types of schools or other regions of the country, it is likely that the availability of calculators to these students is at least as high as in most other parts of the country. It would therefore seem that the percentage of all students taking a calculus examination who would object to the use of calculators might be even greater.

Although there appears to be no basis for changing the calculator policy at this time, the situation regarding calculators seems to be changing. The authors of this report recommend that a survey similar to the one reported on in this document be conducted in 1981 to determine whether the calculus examinations continue to be relevant to curriculum and educational practices before the policy is set for the 1983-84 examinations. In addition to the questions asked on the 1978 questionnaire, teachers should be asked specifically whether calculators should be permitted on AP calculus examinations and, if calculators are permitted, whether the level of sophistication should be restricted. In addition, a student survey similar to the one mentioned in the preceding paragraph but carried out on a broader scale might be conducted at the same time to assess student opinions about the approach that they think would be fairest to the most students.

Appendix A

April 28, 1978

Dear Mathematics Department Chairperson:

The recent rapid increase in the use of hand (pocket) electronic calculators by students has posed a serious question for many educators. Should the use of calculators be allowed in courses and/or examinations? The Calculus Development Committee which has the responsibility for setting the Advanced Placement course descriptions and examinations in mathematics - Calculus AB and Calculus BC - would like to obtain your response to this and other pertinent questions.

The Development Committee is aware of the availability to students of calculators and other aids such as slide rules. At this time, however, the use of calculators or other devices is not permitted in the examination room during the testing period.

Periodically the Committee evaluates its position on such important issues and shortly will be making decisions concerning policies for the administration of the calculus examination in May 1980. In order to arrive at an informed and reasonable policy concerning the use of calculators in the future, the Committee hopes that you will complete and return the enclosed questionnaire. We are enclosing a return envelope for your convenience in responding. We may wish to list, in a report of the results, the names of the schools that participate in this survey, but we will not identify specific results by school.

We hope you will agree to participate in this survey, and we will be happy to share the results with you. Thank you for your time and effort in this endeavor.

Sincerely,

Donald L. Kreider

Donald L. Kreider
Dartmouth College
Chairman
College Board Calculus
Development Committee

/bls

Enclosure

HAND CALCULATOR SURVEY

1978

In order to facilitate the tabulation of results, we are enclosing a machine-scorable card for your responses to questions 1-7. For each of these questions, darken the space that corresponds to each choice that you select.

1. Select every statement below that describes the use of hand calculators in your AP calculus classes. Hand calculators are

   (A) NOT permitted for any purposes.

   (B) permitted for use in doing classwork.

   (C) permitted during some but not all tests.

   (D) permitted during all tests.

2. If calculators are permitted in your class, which statement below best describes the policy you have regarding hand calculators?

   (A) No class time is devoted either to teaching or assisting students in the use of calculators.

   (B) Some class time is devoted to assisting students in the use of calculators and/or in the solution of problems that are best solved with the aid of a calculator, but the course is not modified to include topics that are particularly suited to the use of the hand calculator.

   (C) Use of the calculator is encouraged to the extent that the content of the course is modified to include such special techniques as the numerical evaluation of integrals and the "conjecturing" of certain limits with the aid of a calculator.

3. If your answer to question 2 was C, for which of the following do you teach special techniques that make use of the calculator?

   (A) Numerical evaluation of integrals

   (B) Conjecturing values of limits

   (C) Evaluating functions

   (D) Solving equations

   (E) Changing coordinates

   (F) Other (Please specify in comment section of survey.)

(OVER)

4. If calculators are permitted in your class, what percentage of students use a calculator?

   (A) 100%

   (B) 80% to 99%

   (C) 50% to 79%

   (D) 25% to 49%

   (E) less than 25%

5. If calculators are permitted in your class, are they provided by the school district?

   (A) Yes

   (B) No

Both the multiple-choice and free-response questions on the AP calculus examinations are designed to minimize the amount of arithmetical computation. The opinion of the Development Committee is that the use of calculators on the present examinations would not appreciably affect individual student performance.

6. If the current policy were changed to allow the use of calculators, in your opinion what effect would this have on the performance of your students on the Calculus AB examination as it is presently constituted?

   (A) Student performance would be significantly better

   (B) Student performance would be about the same

   (C) Student performance would be significantly worse

7. If the current policy were changed to allow the use of calculators, in your opinion what effect would this have on the performance of your students on the Calculus BC examination as it is presently constituted?

   (A) Student performance would be significantly better

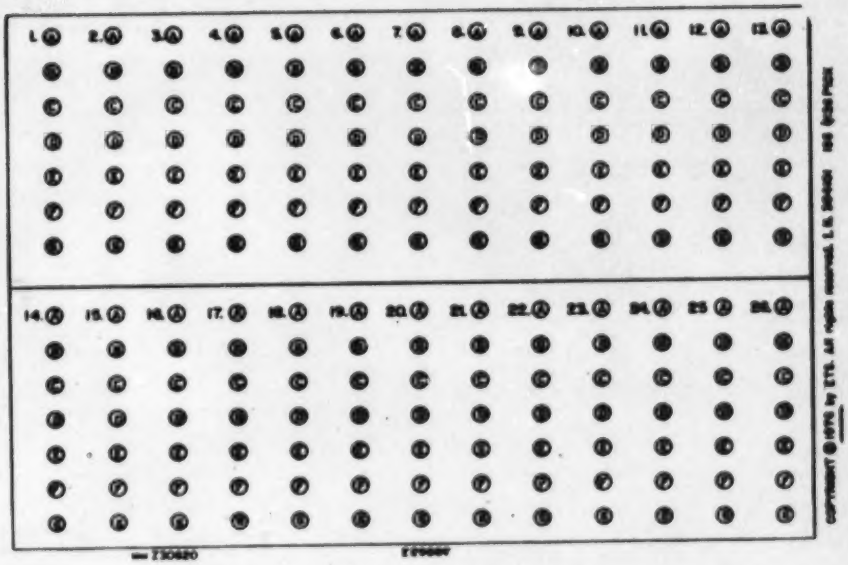
   (B) Student performance would be about the same

   (C) Student performance would be significantly worse

PLEASE PROVIDE THE ADDITIONAL INFORMATION REQUESTED ON THE RESPONSE SHEET ATTACHED TO THE MACHINE-SCORABLE CARD

CLEP SURVEY CARD

Be sure each mark is dark and completely fills the intended space as illustrated here — ● Use a No. 2 pencil only. If you erase, do so completely.



RESPONSE SHEET

8. Approximately how many students in your school are currently enrolled in an AP Calculus course? _____

USE THIS SPACE FOR COMMENTS OR SUGGESTIONS.

☐ I would like to receive a copy of the questionnaire results.

Questionnaire completed by _____
Signature

_____
Name (Please print)

Title _____

Institution _____

Address _____

City, State, Zip _____

Please RETURN THIS RESPONSE SHEET AND THE MACHINE SCORABLE CARD BY MAY 25 to:

Chancey O. Jones
E-201
Educational Testing Service
Princeton, New Jersey 08541

Appendix B

AP Candidate Calculator Questionnaire

1. Did you have access to a calculator that you could have brought with you to take the examination ?

   ☐ Yes ☐ No

2. If a calculator had been provided for your use on the examination, would you have made use of it ?

   ☐ Yes ☐ No

3. Have you had any experience in the use of a calculator ?

   ☐ Yes ☐ No

4. Do you think you could have done better on the examination if you had used a calculator ?

   ☐ Yes ☐ No

5. Which of the following policies regarding the use of a calculator do you think would be fair to the most students ? (Check only one of the following)

   ☐ Calculators should not be permitted for either section of the examination

   ☐ Calculators should be permitted for Section I only

   ☐ Calculators should be permitted for Section II only

   ☐ Calculators should be permitted for the entire examination.

If you think that calculators should be permitted for one or both of the sections, check one of the following.

   ☐ Only non-programmable calculators should be permitted

   ☐ Either programmable or non-programmable calculators should be permitted

End of Questionnaire

Thank you for your help